Internship Research Proposal: Robustness Analysis of Stochastic Dynamics via STL Specifications

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Introduction

The integration of formal methods and control theory has given rise to the field of *symbolic control*, which focuses on designing controllers that ensure systems satisfy logical specifications. A key tool in this domain is *Signal Temporal Logic (STL)*, a formalism used to express complex temporal constraints on system trajectories. While STL-based methods have been successfully applied to deterministic systems, their extension to *stochastic dynamics*—where randomness and uncertainty play a significant role—remains a challenging and underexplored area. Stochastic systems, such as unmanned aerial vehicles (UAVs) operating in uncertain environments, require robust control strategies that can handle noise, disturbances, and unmodeled dynamics. This internship aims to address these challenges by developing robust STL-based controllers for stochastic systems, with a focus on practical applications in UAV control.

Objectives

The primary objective of this internship is to advance the state-of-the-art in symbolic control by developing robust STL-based methods for stochastic dynamical systems. Specifically, the intern will:

- Construct symbolic abstractions of stochastic systems that incorporate robustness margins, enabling the design of controllers that can handle uncertainties in system dynamics and external disturbances.

- Extend the STL framework to account for stochastic behaviors, ensuring that temporal logic specifications can be satisfied even in the presence of randomness and noise.

- Apply the developed methods to UAV control, where stochastic dynamics such as wind disturbances and sensor noise are inherent. The goal is to design controllers that enable UAVs to perform complex missions, such as obstacle avoidance and energy-efficient navigation, while maintaining robustness to uncertainties.

Ideal Candidate

We are looking for a highly motivated candidate with a strong background in control theory, formal methods, and stochastic processes. The ideal candidate should have experience with MATLAB for numerical simulations and a basic understanding of Signal Temporal Logic (STL) and stochastic systems. A passion for solving challenging problems in control theory and a willingness to explore new methodologies are essential. This internship offers an excellent opportunity to contribute to cutting-edge research at the intersection of formal methods and control theory, with potential applications in autonomous systems and robotics.